

Comment on “Observation of a New χ_b State in Radiative Transitions to $\Upsilon(1S)$ and $\Upsilon(2S)$ at ATLAS”

Eef van Beveren¹ and George Rupp²

¹*Centro de Física Computacional, Departamento de Física,
Universidade de Coimbra, P-3004-516 Coimbra, Portugal*

²*Centro de Física das Interações Fundamentais, Instituto Superior Técnico,
Technical University of Lisbon, P-1049-001 Lisboa Codex, Portugal*

PACS numbers: 14.40.Pq, 11.80.Gw, 12.40.Yx, 13.25.Gv

We comment on the recent observation of χ_b states by the ATLAS Collaboration [1] and contest their peremptory interpretation of the highest of the three observed structures as the $\chi_b(3P)$ system. Moreover, we do not agree that from their data the mass barycenter of the $\chi_b(3P)$ system can be determined.

In the first place, it should be noticed that the ATLAS data for the $\chi_b(P)$ systems have a very poor energy resolution, inhibiting an analysis of more detailed structures. Figure 1 compares the presently available ATLAS data for the $\chi_b(1P)$ system with photon data obtained more than 25 years ago [2]. Furthermore, the ATLAS Collab-

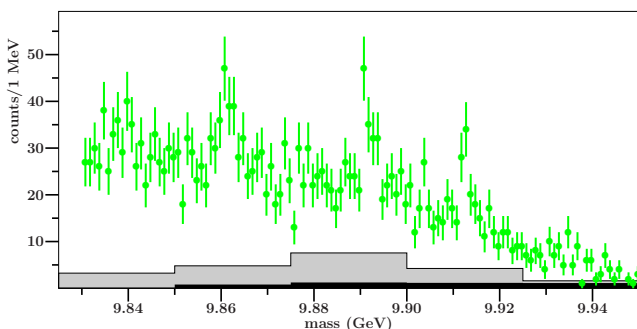


FIG. 1. Photon counts per 1 MeV, assuming transitions $\chi_b(1P) \rightarrow \Upsilon(1S)\gamma$ for converted (gray) and unconverted photons (black) as shown by the ATLAS Collaboration [1], compared to the photon distribution measured by the ARGUS Collaboration [2] (dots and error bars).

oration justifies their interpretation of the data by referring to theoretical work [3, 4] that predicts the $\chi_b(3P)$ system near the highest enhancement in their data [1].

Now, over many years we have been advocating that mesonic resonances are not pure (“quenched”) $q\bar{q}$ states, but can have large meson-meson components, too. Thus, bottomonium systems also contain contributions of open-bottom meson pairs. An adequate approach to study such effects is a coupled-channel T -matrix formalism [5], even below the lowest open-bottom threshold ($B\bar{B}$). When applied to the referred theoretical predictions [3, 4], the results will change substantially [6, 7].

Moreover, the unconverted ATLAS photon data [1] show more structure in the energy region above the $B\bar{B}$

threshold than accounted for in their fit to the data. Indeed, photonic decays will certainly be hindered by strong open-bottom decays above the $B\bar{B}$ threshold. Nevertheless, it is exactly in that region where we expect a triplet ($0^{++}, 1^{++}, 2^{++}$) of χ_b states.

Using the model and parameters of Ref. [6], we find four quenched χ_b candidates at 10.683 GeV, viz. the three $\chi_b(3^3P_{0,1,2})$ states, but also the $\chi_b(2^3F_2)$ 2^{++} , which will mix with $\chi_b(3^3P_2)$ upon unquenching [5]. One of the resulting 3^3P_2 - 2^3F_2 combinations comes out around 10.62 GeV, just like the unquenched 3^3P_0 and 3^3P_1 states, whereas the other 2^{++} mixture ends up as a bound state, below the $B\bar{B}$ threshold, at 10.548 GeV (see Fig. 2).

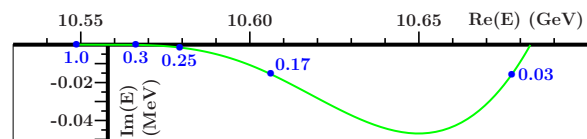


FIG. 2. Resonance-pole movement for lowest 3^3P_2 - 2^3F_2 state, as a function of gradual unquenching. Numbers along curve indicate degree of unquenching.

We thus conclude that the ATLAS Collaboration [1] may very well have observed a single 3^3P_2 - 2^3F_2 state.

This important issue can be settled with a much higher energy resolution, showing whether there is a triplet of J^{++} states around 10.54 GeV or just a singlet.

- [1] [ATLAS Collaboration], Phys. Rev. Lett. **108**, 152001 (2012) [arXiv:1112.5154].
- [2] H. Albrecht *et al.* [ARGUS Collaboration], Phys. Lett. B **160**, 331 (1985).
- [3] F. Daghighian and D. Silverman, Phys. Rev. D **36**, 3401 (1987).
- [4] L. Motyka and K. Zalewski, Eur. Phys. J. C **4**, 107 (1998) [arXiv:hep-ph/9709254].
- [5] S. Coito, G. Rupp and E. van Beveren, Phys. Rev. D **84**, 094020 (2011) [arXiv:1106.2760].
- [6] E. van Beveren, G. Rupp, T. A. Rijken, and C. Dullemond, Phys. Rev. D **27**, 1527 (1983).

- [7] J. -F. Liu and G. -J. Ding, arXiv:1105.0855.